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ABSTRACT

This paper reviewed the research on critical thinking among college students. A total of 62 studies were identified and reviewed. About 62 percent of the studies were longitudinal in nature, and 13 of the 23 studies that attempted to measure student growth in critical thinking employed a cross-sectional design. While a large body of the findings suggested that students grow in critical thinking while in college, much inconsistency emerged as to the factors that affected this growth. Given that studies in this area tend to be homogenous to the extent that they pose the same research questions and employ similar research tools, a surprising amount of inconsistency emerged from the study results. A number of studies suggested that college students make the greatest gains in critical thinking during their freshman year, while courses or programs specifically designed to improve critical thinking have demonstrated mixed results. In comparison to courses taught in a more traditional manner, greater gains in critical thinking scores were found for courses with an instructional paradigm emphasizing problem solving or critical thinking, class participation, and inquiry and higher-order thinking. (Contains 83 references.) (MDM)

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A Review of Research on Critical Thinking

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Abstract

This review of research on critical thinking involves 62 studies. An overview of findings is presented, followed by an analysis of study methodology. While a large body of findings suggests that students grow in critical thinking while in college, much inconsistency has emerged as to the factors that affect this growth. Implications drawn for future research include the need to diversify research designs, measurement instruments, and variables investigated.

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A Review of Research on Critical Thinking

Cultivating critical thinkers is a major goal of American education. Pledges by higher education institutions to instill critical thinking skills in students is commonplace, as most college catalogs will substantiate. A number of well known national reports such as the *National Education Goals Report* (1991), *Integrity in the College Curriculum* (1985), *Involvement in Learning* (1984), *Academic Preparation for College* (1983), and *Action for Excellence* (1983), extol the importance of enhancing students' abilities to think critically and champion heightening efforts to meet this objective. Despite the widely professed centrality of critical thinking development to the educational enterprise, much uncertainty exists as to how educators can most effectively foster this valuable skill.

McMillan's 1987 review of 27 studies on critical thinking at the higher education level is considered by many to be the most significant overview of research on this subject. More than a decade has elapsed since that publication, and the pool of research studies on critical thinking has expanded significantly. A re-examination of the state of educational research on this important topic is thus again warranted. The present study analyzes 62 studies that investigate critical thinking among college students. Study results are organized in two sections. First, an overview of research findings generated by this rich sample of studies is presented. Second, analysis of methodological approaches leads to the address of some salient trends and considerations.

The research studies included in this analysis, which are published in the form of journal articles, dissertations, and books, were identified through searches using the key

words "critical thinking" and "higher education" on such databases as Education Abstracts, ERIC (Educational Resources Information Center), and Dissertation Abstracts. While this sample of 62 studies is extensive, it is not exhaustive. Nonetheless, this sample constitutes a fair representation of the kinds of empirical investigations that have been conducted on critical thinking within the higher education setting.

Critical Thinking Defined

Because critical thinking is a complex skill, any attempt to offer a complete and definitive definition of it would be futile. Like other complex constructs, critical thinking seems to be easier for one to recognize than to define. And, while there is no universally accepted singular definition of critical thinking, there appears to be some agreement as to what the term generally refers to. Educational researchers who tackle the definitional question for the most part do not offer dramatically different interpretations of what critical thinking represents. As noted by Halpren (1993), although absolute agreement on what constitutes critical thinking does not exist, "there is sufficient overlap in the various definitions to allow an evaluator to move beyond the definitional stage."

In a review of the manner in which researchers operationalize critical thinking, Furedy and Furedy (1985) found that critical thinking is typically thought to involve an individual's ability to do some or all of the following: identify central issues and assumptions in an argument; recognize important relationships; make correct inferences from the data; deduce conclusions from information or data provided; interpret whether conclusions are warranted based on given data; and, evaluate evidence or authority.

There have been several notable debates over the construct of critical thinking. One controversy pertains to whether critical thinking is a general skill or a subject-specific skill. According to McPeck (1985), critical thinking is not a content-free general ability even though most tests designed to measure critical thinking treat it as if it were. McPeck argues that because critical thinking is necessarily about some particular thing or subject, it must be a context-specific intellectual skill. As such this skill is dually based, consisting of both a knowledge component and a critical component. Those holding this point of view tend to advocate the teaching of critical thinking only as instruction within subject areas or disciplines. Others argue that while a student's familiarity with subject matter undoubtedly affects a student's performance on thinking tasks in that area, this does not rule out the existence of general principles of critical thinking that have wide applicability and transcend specific subjects (Ennis, 1987; Facione, 1990).

King, Wood, and Mines (1990) point out that confusion over critical thinking also arises due to a failure to address an important distinction between "well-structured problems" and "ill-structured problems." Problem structure is concerned with the certainty by which a solution to a problem can be judged true or correct. On a scale of absolute certitude, well-structured problems have solutions at the high end while ill-structured problems have solutions at the low end. Because the issue of problem structure is not directly addressed in many studies, the precision by which study implications are drawn is often compromised. Commonly utilized measurement instruments such as the Watson-Glaser Critical Thinking Appraisal (WGCTA), Cornell Critical Thinking Test (CCTT), and Reflective Judgment Interview (RJI), because they differ drastically in their inclusion of well- or ill- structured problems (King et. al, 1990),

embody different criteria for critical thinking ability and can potentially yield divergent results. King et. al (1990) estimated the correlation between WGCTA and RJI to be .46, between WGCTA and CCTT to be .76, and between RJI and CCTT to be .46; after correcting for academic ability, the partial correlations for these pairs of instruments are .27, .54, and .27, respectively. Aware that facility with solving well-structured problems does not necessarily entail facility with solving ill-structured problems, Sternberg (1982) urges the development of better instruments to measure the latter and investigations into the relationship between these two skills.

Overview of Research Findings

Growth in Critical Thinking

A generally consistent finding emerging from empirical studies on critical thinking is that significant growth on this cognitive dimension is both perceived (Astin, 1993; Pace, 1974; Tsui, 1998) and experienced by college students (Dressel & Mayhew, 1954; Gunn, 1993; Keeley, 1992; Keeley, Browne, Kreutzer, 1982; King, Wood & Mines, 1990; Klassen, 1983; Lehmann, 1963; McDonough, 1997; Mines, King, Hood, & Wood, 1990; Pascarella, 1989; Rykiel, 1995; Spaulding & Kleiner, 1992). Three of the studies in the sample, however, did not find a significant relationship between educational level and gains in overall critical thinking score (Anderson, 1988; Criner, 1992; Drouin, 1992). In terms of degree of growth, a number of studies report freshmen year growth on tests for critical thinking to be in the vicinity of half a standard deviation. Such a finding emerges from the series of studies conducted by Dressel and Mayhew (1954), which some consider to be among the most comprehensive investigations of

critical thinking (McMillan, 1987; Pascarella & Terenzini, 1991). On a test of critical thinking in the social sciences administered to over 1,700 students at the beginning and end of freshmen year, statistically significant gains of about half a standard deviation (19 percentile points) or better were obtained at each of the eleven participating institutions. On a test of science reasoning and understanding administered to 470 students, Dressel and Mayhew found statistically significant freshmen year gains of about half a standard deviation at six of the seven institutions tested. And, on a general measure for critical thinking (57 items designed to assess one's ability to define a problem, select information pertinent to the problem, recognize assumptions, formulate relevant hypotheses, and draw valid conclusions) administered to 1,000 freshmen, statistically significant freshmen year gains of about half a standard deviation or larger were obtained at all seven participating institutions. Similarly, in a study by Pascarella (1989) in which a matched sample of 47 students were employed, college freshmen year attendance was associated with a gain of .44 of a standard deviation on the WGCTA. In a separate study by Pascarella, Bohr, Nora, and Terenzini (1995), end of freshmen year gains of .41 and .24 of a standard deviation on the Collegiate Assessment of Academic Proficiency (CAAP) were attributed to full-time and part-time students, respectively.

Generally speaking, research reveals more years of education is associated with higher scores on tests for critical thinking. Yet, there is research evidence to indicate that performance on the whole is poor. Norris (1985) reports that competence in critical thinking is reportedly lower than it should be at every level of schooling. According to Kuh (1995), many students who progress through the school system simply are not acquiring the ability to think critically. In a study by Keeley, Browne, and Kreutzer

(1982), in which critical thinking was measured though students' abilities to analyze articles through an essay response format, seniors outperformed freshmen. Yet, the absolute level of performance displayed by seniors revealed "major deficiencies" in critical thinking skills. For instance, 40-60% of the senior group could not provide even a single example of a logical flaw, significant ambiguity, or misuse of data, when asked to evaluate a written passage containing several such errors. Using the same data source, Keeley (1992) analyzed freshmen and senior responses on a task to identify assumptions appearing in an essay and found "poor performance" displayed by both freshmen and seniors. Logan (1976), in a study involving 874 sociology students, concluded that "very low" scores were attained by students at each educational level studied.

Research evidence also suggests that college students make the greatest gains in critical thinking during their freshmen year (Lehmann, 1963), which is consistent with research findings on general cognitive growth (Pascarella & Terenzini, 1991). Moreover, the present analysis reveals that freshmen are more likely than sophomores, juniors, and seniors to participate as subjects in studies on critical thinking. Hence, it is quite possible that generalizations made from study findings on critical thinking may at times lead to an overly optimistic interpretation of the overall impact of college on growth in critical thinking. From these considerations a provocative question arises: why do subsequent college years fail to rival freshmen year in its efficacy to enhance students' critical thinking? Such an important question has been given little attention by researchers.

Instructional Factors

A large proportion of the research studies conducted on critical thinking pertain to specific pedagogical methods. In the sample utilized for this review, approximately 29% of the studies investigate the effect of some pedagogical factor. Mixed results have emerged from these studies. In comparison to courses taught in a more traditional manner, greater gains in critical thinking scores were found for courses with an instructional paradigm emphasizing problem solving or critical thinking (Bailey, 1979), an instructional protocol emphasizing searching for meaning through reading, writing, and class participation (Gibson, 1985), an emphasis on inquiry and higher-order thinking (Suksringarm, 1976), out-of-class assignments designed to increase critical thinking (Eason, 1986), and attempts to elicit a high level of student participation, instructor encouragement, and peer-to-peer interaction (Smith, 1977). A number of instructional factors are positively related to self-assessed growth in critical thinking (Astin, 1993; Tsui, 1998), including having a paper critiqued by an instructor, conducting independent research, working on a group project, giving a class presentation, and taking essay exams; negatively related to this outcome is taking multiple-choice exams.

Nonsignificant effects have been found, however, for courses stressing argumentation and discussion (Beckman, 1956), critical thinking objectives (Dressel & Mayhew, 1954), student-centered active learning (Forbes, 1997), inquiry and higher-order thinking (Hayden, 1978), reflective teaching (Phelps, 1987), as well as for courses employing such teaching techniques as the Guided Design (Hancock, 1981), self-paced instruction (Hardin, 1977), a values clarification approach (Jones, 1974), independent laboratory investigation (Norton, 1985), special manner of student grouping (Fishbein,

1975), and alternative modes of instructions presentation (Coscarelli & Schwen, 1979). In a study in which political science students were exposed to either traditional lecture, an implicit model of critical thinking instruction, or an explicit model of critical thinking instruction, West (1994) found that in none of the sections did students improve their critical thinking skills to a statistically significant degree. Yet, statistically significant positive correlations were detected between WGCTA score and number of writing assignments completed (a component of the implicit model) and between WGCTA and number of critical thinking assignments completed (a component of the explicit model). Cases in which significant effects were not detected for instructional approach have caused some to doubt whether teaching method is relevant to the enhancement of critical thinking skills. Others maintain that failed attempts to establish differential effects on various modes of instruction are likely to be caused by limitations found with traditional research approaches (Smith, 1977).

Curriculum Factors

A significant portion of studies on critical thinking address effects of curriculum. In this sample approximately 26% of the studies include some factor relating to curriculum. Dressel and Mayhew (1954) found that the greatest student gains in critical thinking occurred at colleges with courses specifically devised for general education purposes. These colleges commonly involved the study of basic liberal arts and sciences in an integrative fashion, and emphasized basic integration and synthesis of knowledge rather than discrete bits of specialized information. It is believed that these institutions devote greater attention to developing general intellectual skills and orientations such as

analytical and critical skills, and tolerance for ambiguity (Gaff, 1983). Winter, McClelland, and Stewart (1981) likewise concluded that a curriculum that is focused on an integrative theme encompassing different disciplines leads to greater growth in critical thinking. The students who were exposed to the integrative program began with higher scores (1.66 versus 1.22) and achieved greater gains (an increase of .50 versus .08) than did the control group. These conclusions are congruent with findings by Astin (1993) in which students' self-reported growth in critical thinking is positively related to taking interdisciplinary courses, and attending an institution with a humanities orientation and where there is heavy faculty involvement in teaching general education courses. In a study involving 431 college students, Beckett (1996) found that programs stressing experiential learning processes and self-directed learning processes positively influenced student scores on the WGCTA. Annis and Annis (1979), in a study involving 121 students enrolled in Introduction to Philosophy, Logic, Ethics, and a nonphilosophy control class, found that when compared to the control group the Logic course had a consistent impact on certain aspects of critical thinking while the other philosophy courses did not.

Courses or programs specifically designed to improve critical thinking have demonstrated mix results. Logan (1976) found superior skills were displayed by students who had enrolled in a sociology course with the explicit goal of teaching students to think critically, logically, and more scientifically. Moll and Allen (1982) discovered that students enrolled in a biology course specifically designed to improve both biology content knowledge and critical thinking skills made significant improvements on a locally developed instrument measuring both dimensions. However, no significant gains

were found for a special foundation research course on critical thinking (Gressler, 1976), or a psychology course designed specifically to enhance critical thinking (Lyle, 1958). A trail of mix findings regarding courses on critical thinking is not surprising when one considers how coursework with the same objectives and which seemingly address the same subject matter may differ vastly from one another across institutions in both approach and results. Halpren (1993) cautions that researching the effects of courses on critical thinking can be tricky. This is because a comparison of students who have and have not taken the course represents a methodological flaw in so far as such courses are usually required in the general education program at those colleges and universities where they are offered (i.e., those who have avoided taking the course differ in some fundamental way from those who take the course in the sense that they have somehow managed to avoid taking a required course). Some critics argue that critical thinking courses, mostly those based on informal reasoning, might be ineffectual to the extent that they encourage sophistry by teaching students skills that they can then use to rationalize their existing biases (Paul, 1982, 1986). According to Kurfiss (1988), there have been too few critical thinking programs implemented so far to reach a firm conclusion about their effectiveness.

Disciplinary Field

The investigation of effects of disciplinary major on critical thinking is found in approximately 16% of the studies included in this review. Generally speaking, a majority of studies have found no differences in critical thinking score across disciplines, and even in cases in which differences are detected they tend to dissipate after academic aptitude or

initial critical thinking ability is controlled for. Spaulding and Kleiner (1992) found that students with highly developed critical thinking skills are not self-selecting into particular college disciplines; majoring in liberal arts, social science, math/physical science, business and health science were not predictive of the student's score on the CCTT. McDonough (1997), in a study of 240 community college students, found no disciplinary effects on WGCTA scores. Money (1997) did not detect any differences in CCTT scores by students pursuing business, music, or nursing studies. Moll and Allen (1982) also did not find any test score differences in critical thinking by biology and nonbiology students. Simon and Ward (1974) also did not find differences in WGCTA score between those enrolled in an arts program and those enrolled in a science program. Terenzini, Springer, Pascarella, and Nora (1995) found that the number of courses taken in different disciplinary areas was related to post-test scores in critical thinking at the end of freshmen year (number of math classes was negative, while number of science courses was positive), but these effects disappeared when precollege critical thinking was controlled. King, Wood, and Mines (1990) found that on the RJI, social science majors earned higher scores than math science majors at the graduate level; no such difference was detected for the two groups at the undergraduate senior level. On both the WGCTA and CCTT, math science majors earned higher scores than social science majors, but such differences disappeared after controlling for academic aptitude. Disciplinary differences, however, were detected in a study by Gunn (1993) who found social science majors achieved higher scores than nonsocial science majors on the Wasatch Test of Critical Thinking. The number of courses taken in certain disciplinary areas such as history,

science, math, foreign languages, and ethnic studies has been found significantly and positively related to self-assessed growth in critical thinking (Astin, 1993; Tsui, 1998).

Other Factors

The relationship between critical thinking ability and a number of skills has been researched. In a study involving 302 students, Anderson (1988) found a significant relationship between moral judgment and critical thinking for the female group but not the male group. Brabeck (1980) concluded that critical thinking is necessary but not sufficient for the development of superior reflective judgment in an analysis of the test performance of 392 students which revealed that on the RJI those with high WGCTA scores outperformed those with low WGCTA scores. While those with low WGCTA scores scored uniformly low on the RJI, there was much greater variability in RJI scores by those with high WGCTA scores. Mines et. al (1990) showed that those who reasoned at higher stages of reflective judgment also demonstrated superior critical thinking skills. In a study involving 63 freshmen, Luckett (1991) found that critical thinking skills is positively related to both writing skills and reading skills. In analyzing scores on the CCTT, Steele Hanson (1986) found that more variation in critical thinking performance was accounted for by computer ability than mathematical ability. Research findings regarding critical thinking ability and college grades (or academic aptitude) are inconsistent as Hill (1995), Spaulding and Kleiner (1992), and Smith-Sanders (1997), uncovered evidence of a significant association while Criner (1982), Money (1997), and Pascarella (1989) did not.

Gains in critical thinking are significantly associated with attending college full-time (Pascarella, Bohr, Nora, & Terenzini, 1996) and residing on campus (Pascarella, Bohr, Nora, Zusman, Inman, & Desler, 1993). Economic status was found neither to be related to critical thinking skills (Criner, 1992) nor freshmen gains in critical thinking (Pascarella, 1989). And, while Criner (1992) found no correlation between parent education and critical thinking performance, Terenzini et. al (1995) found parent education level to be significantly associated with gains in critical thinking during freshmen year.

Inconsistent findings also emerge concerning gender differences related to critical thinking. In several studies evidence of such differences was found (Gunn, 1993; Pascarella et. al, 1996; Simon & Ward, 1974), but a greater number have found no evidence of such differences (Anderson, 1988; Hill, 1995; Klassen, 1983; Moll & Allen, 1982; Money, 1997; Pascarella, 1989; Terenzini et. al, 1995; Lehmann, 1963). Gender has been found to interact with number of philosophy courses taken (Annis & Annis, 1979) and institutional type (Pascarella et. al, 1995) in predicting gains in critical thinking. With regard to critical thinking differences related to race, a modest but significant relationship was found in one study (Pascarella et. al, 1996) but not in three other studies (Hill, 1995; Pascarella et. al, 1989; Terenzini et. al, 1995). Race was found to interact with institutional type in the study by Pascarella et. al (1995) as greater gains in growth thinking was demonstrated by nonwhite students at 2-year colleges and by white students at 4-year colleges.

Only more recently have out-of-class experiences received attention by those researching critical thinking. Employing the Collegiate Assessment of Academic

Proficiency (CAAP) and Pace's College Student Experiences Questionnaire (CSEQ), Terenzini et al. (1995) found that, even with precollege critical thinking controlled, students' out-of-class experiences contributed as much to gains in critical thinking at the end of the freshmen year as did their class-related experiences (2.9 percent and 2.5 percent, respectively). The number of unassigned books read by students and the amount of time spent studying were found to positively affect critical thinking scores. Somewhat surprising, however, was the finding that gains in critical thinking scores were negatively related to students' perceptions of the quality of their relationships with peers. Analyzing data from 24,847 college students, Astin (1993) found that being a guest in a professor's home and attending an institution where there is a strong student orientation among the faculty are positively related to self-assessed growth in critical thinking.

Utilizing a multiple institution sample of 1,054 students, Edison (1997) found that participation in out-of-class activities made a small but statistically significant contribution to gains on the CAAP. Faculty interaction and athletic or recreation facilities use were negatively associated with critical thinking scores. There is research evidence to support that hours spent outside of the classroom discussing racial or ethnic issues (Astin, 1993) or current issues with others (Smith-Sanders, 1997) positively influence students' growth in critical thinking. Rykiel (1995) found that community college students who worked off campus 25 hours or more a week had higher critical thinking scores than those working less than 20 hours. Neither Criner (1992) nor Pascarella et. al (1993), however, found a relationship between number of hours worked and critical thinking performance. Jackson (1961) investigated the effects of participation in debate on critical thinking and found mixed results as debaters

experienced significantly greater gains than the control group at five colleges, but smaller gains for debaters than the control group at four other colleges.

Evidence reviewed by Pascarella and Terenzini (1991) suggests that for such general cognitive outcomes as critical thinking the impact of any one academic or nonacademic experience may not be as important as students' total level of engagement in the academic and social systems of the institution. This is congruent with previous research on the positive effect of general student involvement or quality of effort on cognitive development (Astin 1977, 1993; Pace, 1984). In a study by Pascarella (1989) various individual academic or social experience variables such as resident arrangement, time spent studying, extracurricular activities, and number of intellectually focused interactions with faculty and peers, were shown to have only trivial and statistically nonsignificant relations with critical thinking growth during the freshmen year. Yet, when these variables were combined into a composite variable representing social and intellectual involvement, a statistically significant positive association (partial r=.34) was found.

Methodological Considerations

Research Design

Approximately 52% of the research studies in this sample employ both pre-test and post-test. That about 38% of the studies are not longitudinal in nature should be of some concern. Fifty-seven percent (13 out of 23) of the studies in this sample that attempt to measure student growth in critical thinking employ a cross sectional design. The use of such a methodological approach is problematic due to the effects of college

attrition. Researchers might be mistakenly inferring higher critical thinking test scores of upperclassmen as evidence that college attendance positively affects students' abilities to think critically. Such a judgment is dubious because those who are adept at critical thinking are bound to be less likely to drop out of college than those who are not adept at critical thinking. Hence, in research studies utilizing a cross sectional design some of the "measured gains" in students' critical thinking abilities might be inappropriately attributed to college exposure. Also in need of further attention in this area are the effects of maturation on critical thinking which occur independent of college attendance. This issue is not well researched since there appears to be only one study (Pascarella, 1989) wherein a college attending group is compared with a matched non-college-attending group, albeit using a relatively small sample of 47 participants.

Even among those studies which are longitudinal a serious concern is raised by the typically short period that transpires between pre-test and post-test. In most cases treatment duration is usually no longer than a school year, and is frequently as brief as a quarter or semester term. Such a brief time span is problematic for it might not be long enough for true treatment effects to manifest. This methodological weakness may account for the generally inconsistent results that have emerged from research on the effectiveness of instructional techniques, and courses and programs specifically designed to enhance students' critical thinking skills. Investigations of growth in critical thinking from enrollment in a specific type of course are further complicated by such potential mediating factors as instructor differences and simultaneous exposure to other coursework.

Another concern regarding research design is that most studies do not involve very large samples, nor multiple institutions. Approximately half of the studies employ samples of 200 or fewer students, while a fourth of the studies in this analysis employ samples of 100 or fewer students. Less than a third of the studies drew their sample from more than one institution. Without adequate research involving multiple institutions it is impossible to investigate the effects of institutional level variables.

Measurement Instruments

A somewhat limited range of measurement instruments has been used in critical thinking research. In terms of measuring students' critical thinking abilities, the most commonly adopted approach involves standardized written multiple-choice tests. Benefits associated with the employment of standardized instruments have led the Watson-Glaser Critical Thinking Appraisal (used in 47% of the studies), Cornell Critical Thinking Test (used in 11% of the studies), and Collegiate Assessment of Academic Proficiency (used in 10% of the studies) to be the most frequently utilized in critical thinking research. Such measures, however, are not without weaknesses and limitations (see Berger, 1985; Helmstadter, 1985; Modjeski & Michael, 1983). A comparative evaluation of the WGCTA and CCTT were conducted by a panel of psychologist (Modjeski & Michael, 1983). Both tests obtained highly unfavorable valuations in the context of possible bias and lack of cross-validation efforts. Moreover, both measures were judged quite negatively in terms of stability of scores derived from the use of parallel forms across administrations. Norris (1985) cautions that critical thinking is extremely sensitive to context. McMillan (1987) warns that tests like the WGCTA are

too general to capture growth in certain areas of critical thinking, especially in the short-term, and may not be sufficiently domain specific to detect the influence of academic major or academic concentration. McPeck (1985) is critical of efforts that assume that a skill as complex as critical thinking can be adequately gauged by any multiple-choice exam. Berger (1985) alerts users not to overlook the fact that these purported *thinking* tests appraise critical thinking through *reading* (it is unclear as to whether a similar test administrated verbally would yield the same scores).

Because multiple-choice tests have been criticized for measuring only *product* (answers to test questions) while neglecting *process* (how the application of critical thinking skills leads to answers), some researchers attempt to investigate process through analyzing verbalized or written responses to tasks designed to elicit critical thinking. For example, Winter and McClelland (1978) developed the Test of Thematic Analysis to elicit complex concept formation by asking students to read two groups of stories and then to write about their differences. Similarly, in studies by Keeley (1992) and Keeley et. al (1982) essay tests were administered wherein students were asked to read an essay then to evaluate the passages by answering some open-ended questions (e.g., "identify and explain an ambiguity"). The focus here, according to Keeley et. al (1982), is "less on what the student can recognize among a number of different quality possibilities and more on what the student can find or generate for himself." These approaches to studying critical thinking, however, are infrequent as only a handful of the studies in this sample employed such measures.

Insight into critical thinking has been derived from students' self-reported data. Pace (1974), Astin (1993), and Tsui (1998) have conducted research using students' self-

assessed growth in critical thinking. Self-reported data has been much utilized in research pertaining to students' general cognitive development (see Pascarella & Terenzini, 1991). Although some skepticism about the validity of a self-reported measure is expected, there is support for its usability. Bowen (1977) observed a general similarity between the results of cognitive outcome studies based on objective measures and those derived from students' self-reports. And while self-reported cognitive abilities does not correspond perfectly with actual test scores, Pike (1996) found an adequately stable relationship existing between the two to warrant the use of self-reported data as general indicators of achievement. Moreover, both Astin (1993) and Anaya (1992) have found moderate positive correlations between self-reports and seemingly more objective measures of growth. In their review of the research literature on higher education, Pascarella and Terenzini (1991) concluded that student self-reports represent a "reasonable, if not totally adequate, indicator of cognitive growth." Others advocate the use of indirect indicators such as self-reported data primarily because of the extreme difficulty of producing direct indicators (Ewell and Jones, 1993).

It is quite clear that no single measure of critical thinking is perfect. In selecting the most appropriate instrument to measure the ability to think critically, one needs to seek the most suitable match between the specificity of the research question at hand and the strengths, weaknesses, and distinct characteristics of various instruments. Given that any choice made will entail limitations, advancement of knowledge becomes all the more reliant about the ongoing accumulation and constant challenge of evidence drawn from a diversified bounty of studies. Since a majority of studies on critical thinking focus on classroom factors, future research efforts should consider the use of such qualitative

methods as classroom observations and participant interviews--investigative tools that have thus far been largely bypassed.

Variables

Clearly the primary focus of research on critical thinking has been on classroom experiences. And while such investigations are worthwhile, there needs to be more research involving out-of-classroom factors. Inquiry into the effects of any form of out-of-class experience on critical thinking skills development appears in only 9 out of the 62 studies in the present sample. This is disconcerting since both personal experience and research suggest that a significant amount of student growth can be attributed to students' out-of-class experiences. The potential effects of peer group influence and engagement in college activities outside the classroom have been little studied. Future research should also consider institutional level variables such as institutional type, faculty-student ratio, per-student instruction expenditure, and elements within the campus culture which may significantly impact student growth in critical thinking.

Conclusion

Although the virtue and imperative of critical thinking is widely espoused, there is surprisingly little known through empirical research about the development of critical thinking in college (Keeley & Browne, 1986). While we are fairly confident that students' abilities to think critically grow during college, there is much less known about what actually enhances critical thinking. Given that studies on this subject tend to be somewhat homogenous to the extent that they pose common research questions, (certain

instructional techniques or curriculum offerings designed to enhance critical thinking are effective) and employ similar research tools (primarily standardized tests of critical thinking), there is a surprising amount of heterogeneity (inconsistencies) emerging from study results. This review highlights a number of concerns that arise concerning research conducted on critical thinking. Because relatively little substantial knowledge has emanated from past research on critical thinking, more exploratory research involving the simultaneous control of a wide spectrum of variables would be beneficial. Since our best understanding of critical thinking will not come from any single research endeavor, but rather the critical examination of findings from a range of research studies, diversifying research design, measurement instruments, and variables investigated will be integral to expanding our understanding about this complex skill that is likely to be affected by a mosaic of sources within the higher education setting.

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